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Department of Agroecology, Institute of Ecology, Turew

Jerzy KARG

AN ATTEMPT TO ESTIMATE THE ENERGY FLOW THROUGH THE POPULATION OF COLORADO BEETLE (*LEPTINOTARSA DECEMLINEATA* SAY)*

(Ekol. Pol. 21:239–250). The abundance and reduction of Colorado beetle and the consumption of potato leaves were compared in conditions of chemical control and without. The last larval stage (L_4) attains 6–8% of the initial number of eggs in the years with chemical control applied, and 15–31% in the years without chemical control. The consumption of potato leaves is also high in the years with chemical control which does not decrease the tuber crop. The energy consumed by the Colorado beetle larvae and energy returning into the habitat in the form of faeces is determined. The profit due to the presence of the shelterbelt is about 60 kcal/m^2 during the season. The ratio of the faeces to consumption is about 50% on the average.

1. INTRODUCTION

The aim of the research was to determine the amount of energy absorbed by the Colorado beetle (*Leptinotarsa decemlineata* Say) population from the primary production of potato field and the percentage of energy returning to the habitat in the form of faeces. The data on the abundance and reduction of the Colorado beetle larvae and imagines were obtained during the period of six years (1965–1970). The data on the energy balance of Colorado beetle are taken from the papers by Chłodny, Gromadzka and Trojan (1967) and Chłodny (1967).

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During the first four years (1965–1968) the studies were conducted in order to observe the population development of Colorado beetle without the chemical control. Special attention was paid to the problem of natural reduction to determine its range and explain the mechanisms by studying the significance of some biocenotic elements responsible for the reduction. The studies being conducted each time throughout the year allowed to obtain data on the changes of the abundance in different moments of the development of Colorado beetle population. The chemical control was applied again in 1969 and therefore the comparative data allowed to draw conclusions about the efficiency of applied insecticides.

2. AREA AND METHODS

The studies were conducted on the fields of the Plant Culture Station at Rogaczewo Małe, Kościan district, Poznań province. The examined fields of 4 ha surface were adjoining on one side the shelterbelt. Detailed descriptions of the shelterbelt and climatic conditions can be found in the earlier papers (Karg and Trojan 1968, Karg and Mazur 1969, Karg 1970) and other ones (Kutera 1956, Jansz 1959, Jaworski 1960, 1962, Jakuszewski 1967, Kamiński 1968).

The number of eggs and larvae of all development stages and of imagines found on potato plants was estimated by combing out particular plants, but all the above mentioned development stages of Colorado beetle from one plant were the quantitative sample. The total of 120 samples were taken from an 1 ha surface, which was a section of the whole field. The sampling frequency (every two days) depended on the duration of the shortest living stage (L_2) in order that the life time of stage L_2 be equal or longer than the lapse of time between the sampling of two series of samples. The person collecting the data moved along the field in a broken line checking every fifth potato plant in the every second ridge. Such method allowed to sample evenly the entire surface without scrutinising the same plant several times.

The calculation methods (Karg and Trojan 1968, Karg 1969) were based on the known number of potato plants per surface unit (1 m^2), on the number of eggs and larvae on one plant and the duration of particular development stages. The extent of reduction was estimated by comparing the abundance of particular development stages and expressed by its percentage as related to the initial number of eggs or the preceding stage. The reduction of eggs was estimated directly on the basis of the known number of alive and destroyed eggs.

3. NUMBER DYNAMICS AND REDUCTION

The number of eggs did not vary much during all the years of studies. The curve of number dynamics of eggs had also a similar course. The differences were only in the period of egg appearance and of maximum density, which varied in different years according to the period of potato sprouting and thermal conditions. On the whole the number of eggs, in the years without insecticides and in those with chemical control, increased rather quickly in the first ten days, but the high density did not last long (Figs. 1, 2). The period of small number level lasted 30–40 days at densities of the order 10 eggs/m^2.

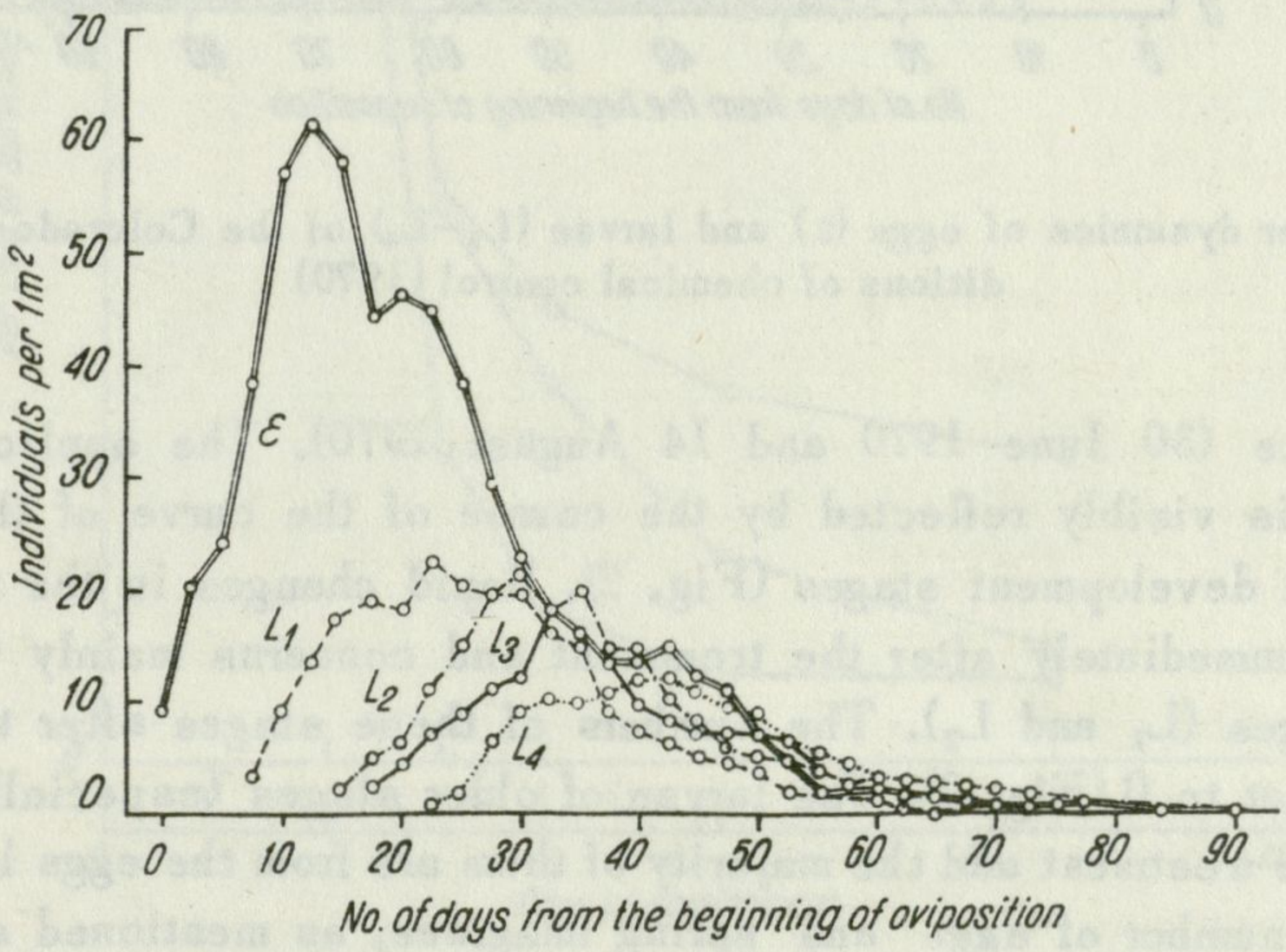

Fig. 1. Number dynamics of eggs (ε) and larvae (L_1 – L_4) of the Colorado beetle in conditions of no chemical control (1965–1968)

The course of number dynamics of the larvae of all stages in the years without chemical control (1965–1968) was characterized by a generally quick increase of densities up to the maximum and then by a slow decline, but the older the stage (Fig. 1) the more even was the course of the curve. The moments of the appearance of particular stages in the field, and also those of maximal values shifted in time but corresponded in the general outline to the life span of these stages. At first the number of larvae increased (in 1966) in the first year without chemical control, and then decreased in the last year of investigations without chemical control attaining values approximate to those in 1965.

Since 1969 the chemical control with the insecticide "Ditox" began, in 1969, 21 kg/ha (2 August 1969) were applied once, and in 1970, 25 kg/ha were

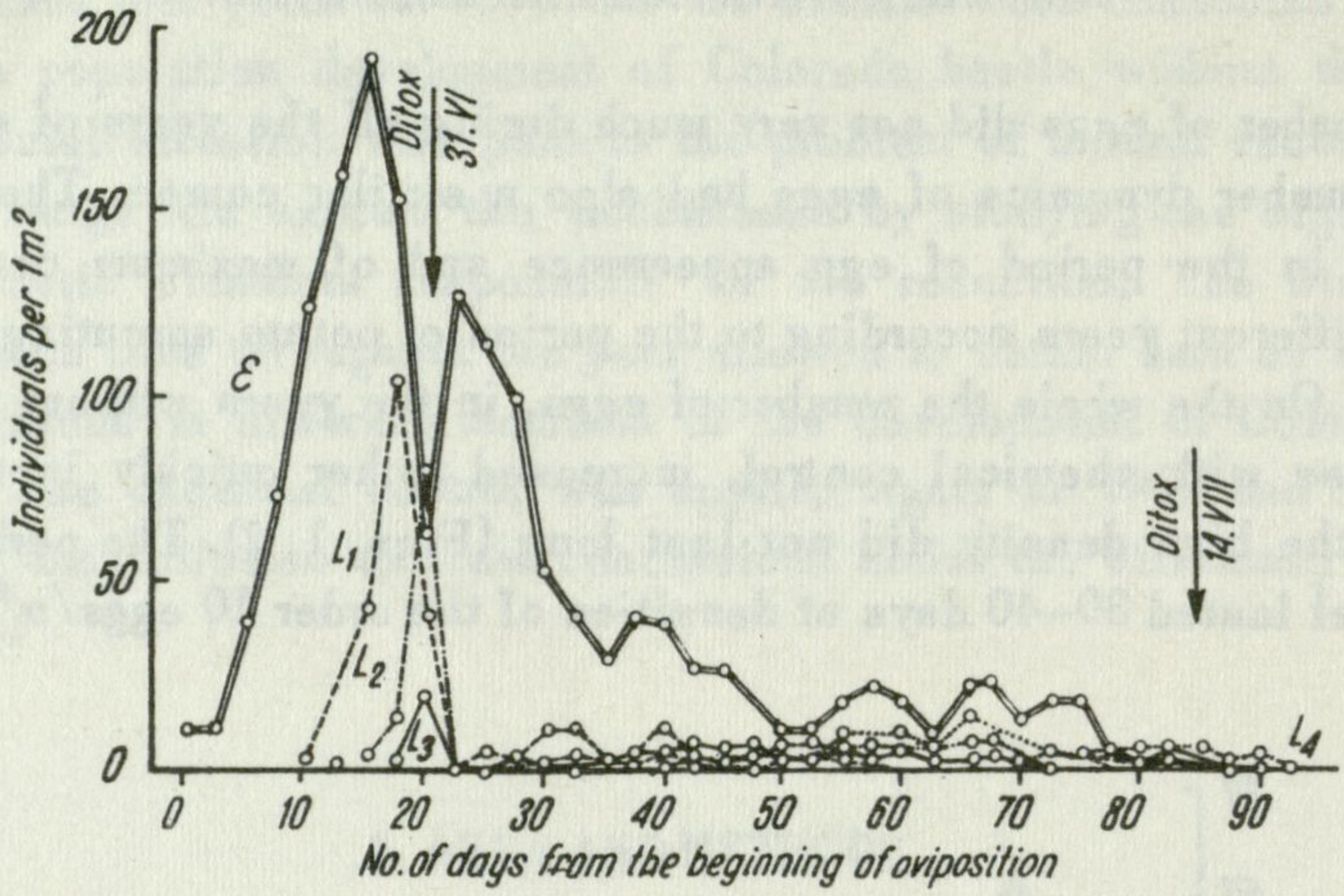

Fig. 2. Number dynamics of eggs (ε) and larvae (L_1–L_4) of the Colorado beetle in conditions of chemical control (1970)

applied twice (30 June 1970 and 14 August 1970). The application of the insecticide is visibly reflected by the course of the curve of the number of larvae of all development stages (Fig. 2). Rapid changes in the number level take place immediately after the treatment and concerns mainly the larvae of younger stages (L_1 and L_2). The numbers of these stages after the treatment decline almost to 0 (Fig. 2). The larvae of older stages (especially L_4) appear only after the treatment and the majority of them are from the eggs laid in a later period. The number of eggs and spring imagines, as mentioned above, do not decrease due to the insecticide, which proves the small toxicity of the applied preparation for the females of Colorado beetles and the eggs laid by them. The comparison of the average abundance in the years without chemical control (1965–1968) with that in the years with chemical control (1969–1970) showed no greater differences and especially in the case of older larval stages (Tab. I).

4. REDUCTION

Similarly as in the case of the number of eggs their reduction did not display any greater differences and ranged through all the years of studies (those with and without chemical control) within several per cent. In the period preceding the application of the insecticide the biocenotic reduction caused by the predatory elements of the field entomofauna undoubtedly actshere. But the biocenotic reduction takes place also after the application of the insecticide, but in the case of larvae it is impossible to determine its range because of the

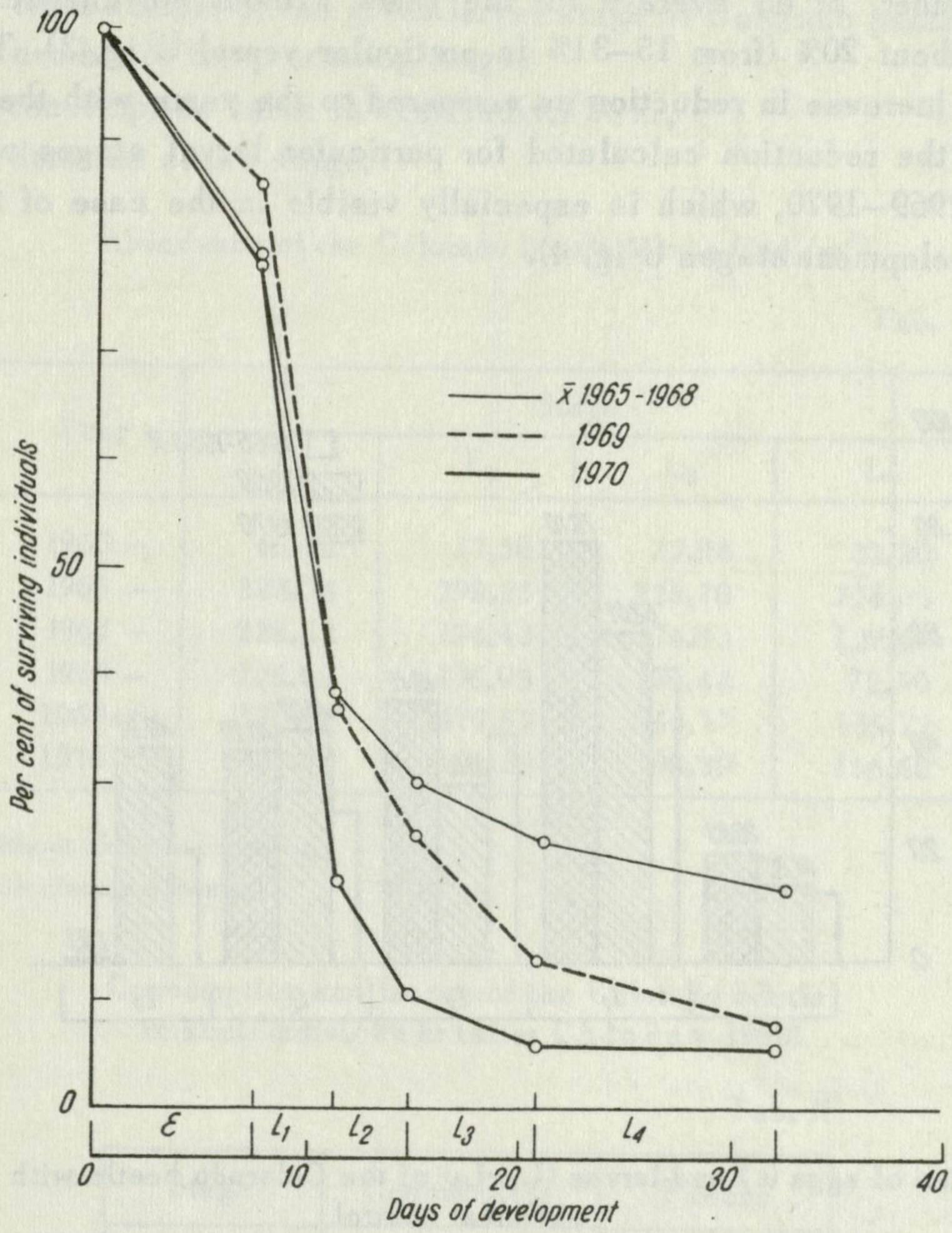

Fig. 3. Survival of eggs (ε) and larvae (L_1–L_4) of the Colorado beetle with and without chemical control

„obscuring" action of the chemical agent, probably also causing the decrease of the number of organisms responsible for the reduction of the Colorado beetle. An indirect proof of the existence of biocenotic reduction in that period is the differentiated number of the Colorado beetle larvae in the gradient of the distance from the shelterbelt (the biocenotic reduction varies for different distances from the shelterbelt – Karg 1969), despite the even application of the insecticide on the examined field.

The survival of the larvae of all development stages (in per cents of the initial egg number) is smaller in the years with the chemical control. This means that about 8% attains the last larval stage in 1969 and 6% in 1970 of the initial egg number, at an average for the years without the chemical control

initial egg number, at an average for the years without the chemical control (1965–1968) about 20% (from 15–31% in particular years) (Fig. 3). This is an almost double increase in reduction as compared to the years with the chemical control. Also the reduction calculated for particular larval stages was higher in the years 1969–1970, which is especially visible in the case of the larvae of younger development stages (Fig. 4).

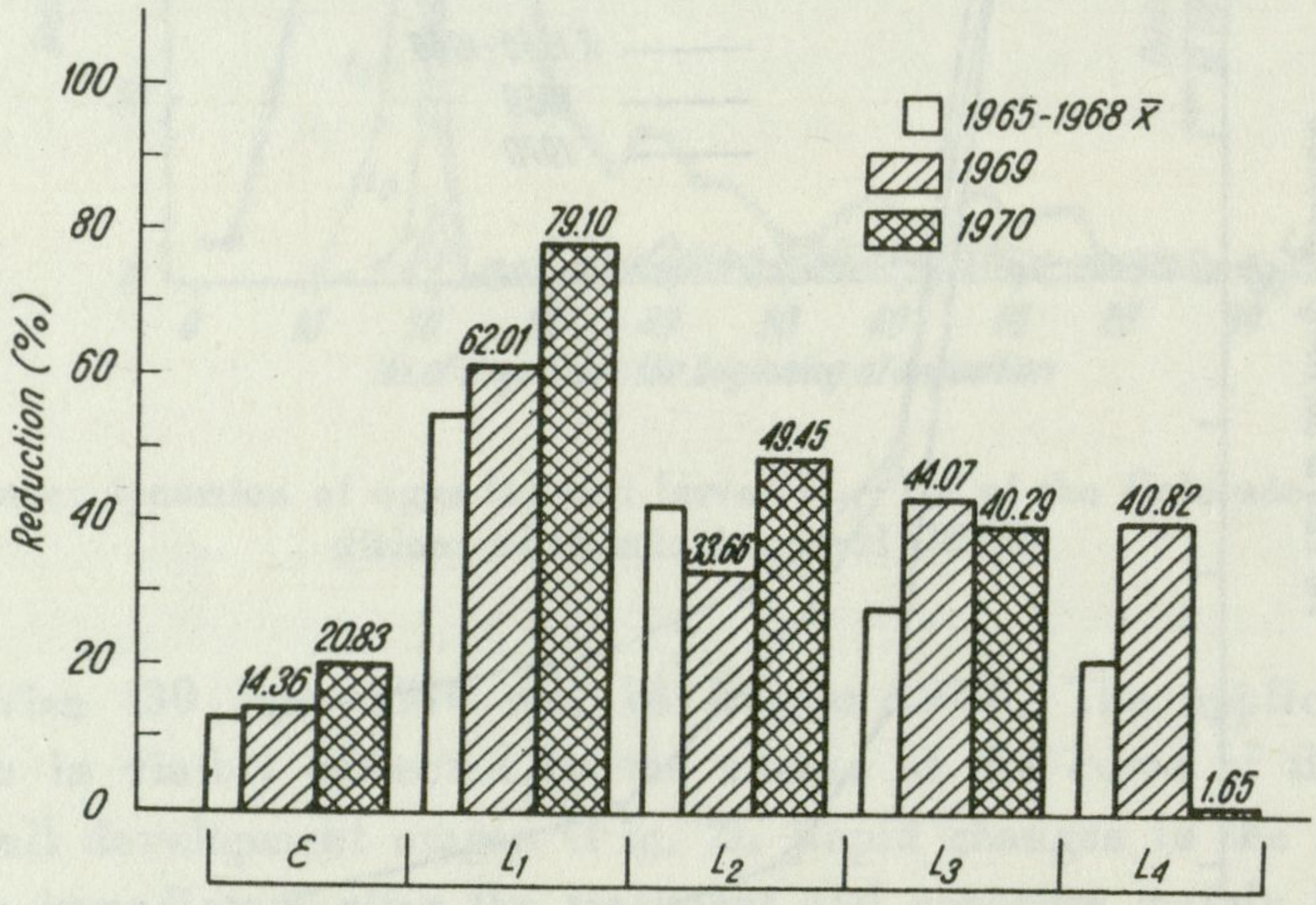

Fig. 4. Reduction of eggs (ε) and larvae (L_1–L_4) of the Colorado beetle with and without chemical control

5. ENERGY BALANCE

The data on the energy balance of the Colorado beetle are from the studies conducted by Chłodny in the years 1965–1967 in conditions close to field ones (Tab. II). In the present studies the two basic components of the energy balance are taken into consideration: food consumption and the excretion of faeces. All the data are expressed in kcal/m^2.

The greatest food demand is displayes by L_4 larvae and imagines. They remain the longest on the culture, which decides about their basic significance as consumers of the green mass of potato. At a known number of particular development stages, their duration and reduction extent, the amount of leaves consumed during the season is calculated according to the formula:

$$(N_1 \cdot C \cdot T) + [(N_0 - N_1) \cdot C \cdot \frac{1}{2} T],$$

where: N_1 – final number of the given larval stage of Colorado beetle,
N_0 – number of the preceding stage,
C – consumption value in kcal/indiv./24 hr,
T – duration of the stage.

Abundance of the Colorado beetle larvae (ind./m^2)

Tab. I

Year	Stage			
	L_1	L_2	L_3	L_4
1965 –	46.13	37.50	32.94	32.30
1966 –	383.04	298.23	223.70	174.05
1967 –	238.62	194.43	174.83	127.48
1968 –	126.08	106.95	100.44	72.90
1969 +	710.26	470.52	263.17	155.73
1970 +	359.09	181.52	108.39	106.60

– = years without chemical control,
+ = years with chemical control

Consumption and faeces of the Colorado beetle in kcal/indiv./24 hr (after Chłodny 1968)

Tab. II

Stage	Consumption	Faeces
L_1	0.0082	0.0057
L_2	0.0092	0.0049
L_3	0.0242	0.0094
L_4	0.0781	0.0459
Imago	0.0339	0.0169*

*Assumed as half of the consumption by imagines.

These calculations are based on an assumption that the larvae dying in the given stage lived on the average half as long as the duration of this stage.

In particular years of studies (Fig. 5) the consumption increased (in the first years without the chemical control), then decreased to increase again in the first year after the insecticide was applied again.

A very important moment, directly affecting the future crop is the period of the most intensive consumption by the Colorado beetle. Intensive consumption in the initial period of potato development, before the florescence, causes

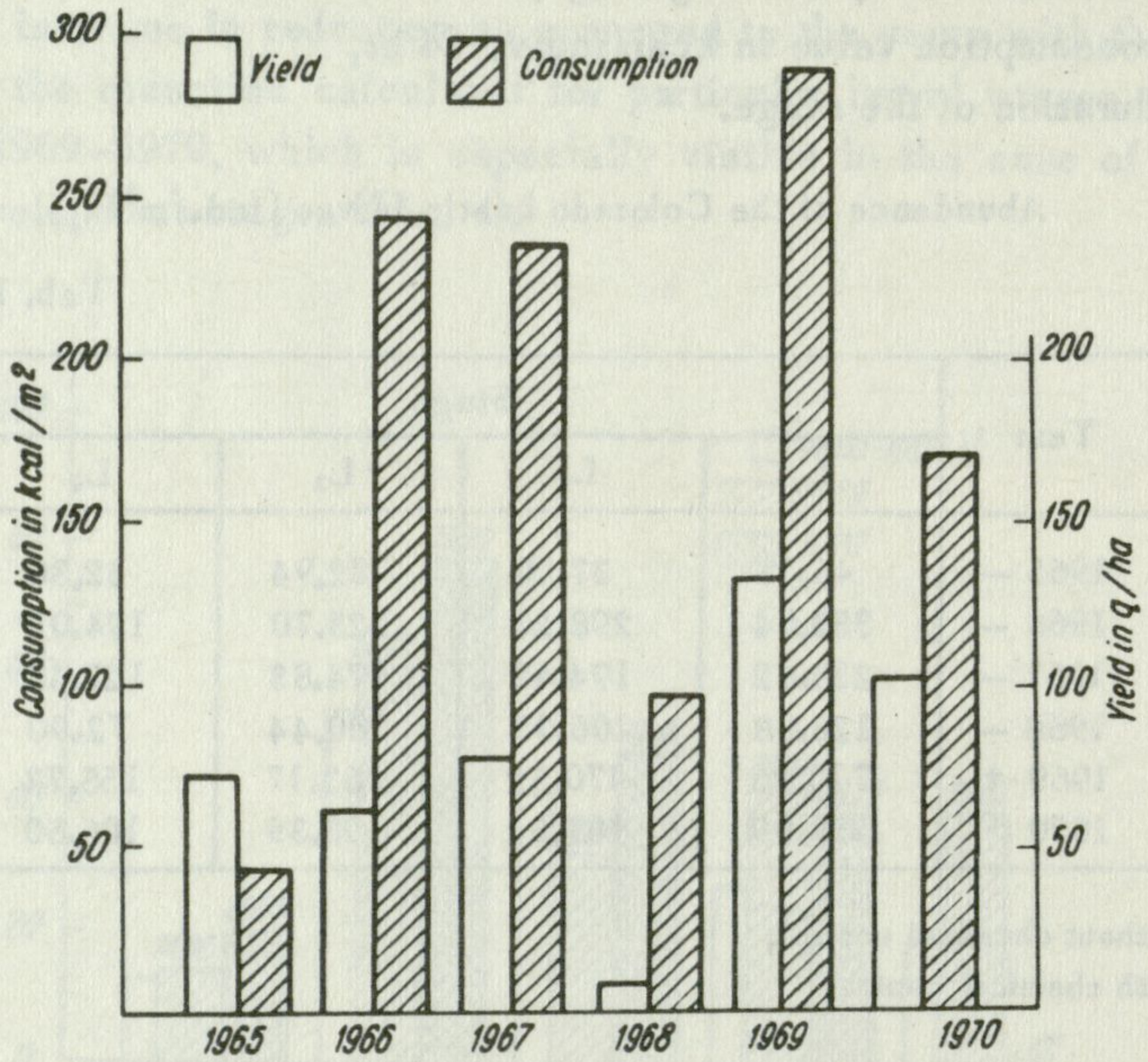

Fig. 5. Consumption of potato leaves by larvae and spring imagines of the Colorado beetle and the yield of potato tubers in conditions of chemical control and without

a considerable decline of the yield (Skuhravý and Makeš 1965, Skuhravý and Ružička 1965). This phenomenon occurred in 1967 and 1968. Even a considerable loss of green mass of leaves causes only a slight decline of yields, but under the condition that it takes place in the later period of plant development. The use of the insecticide at the right moment, chosen acc. to the data on the development of Colorado beetle population and of the host plant, decreases the abundance of the pest in the period most dangerous for the potato growth. After some time the Colorado beetle population is again abundant, but this does not affect negatively the yield. And so in 1969, 1970 the yield from the examined fields did not differ much from the average yield for the Wielkopolska region. This explains the apparently paradoxical phenomenon of much higher yields in the years with an also higher consumption by the Colorado beetle (Fig. 5). In the years 1969–1970 the chemical control caused that greater consumption (Tab. III) took place in the later period of potato vegetation.

This shows that attempts should be made to coordinate the period of chemical treatment with the development of the population of the Colorado beetle larvae in the field. The indicator should be the moment, in which the

Consumption of the Colorado beetle in two periods of vegetation season in kcal/m^2 (1970)

Tab. III

Period stage	Before inflorescence	After inflorescence	Total
L_1	5.7	5.3	11.0
L_2	5.6	3.1	8.7
L_3	8.6	10.5	19.1
L_4	–	93.9	93.9
Imago	–	22.7	22.7
Total	19.9	134.5	154.4

population of Colorado beetle larvae attains its full development, i.e., the appearance of L_3 larvae on the field, or possibly the beginning of the appearance of L_4 larvae. On the other hand it is important that the date of insecticide treatment concurrs with the inflorescence of potato. And therefore, potato varieties with a shorter vegetation period should be prefered.

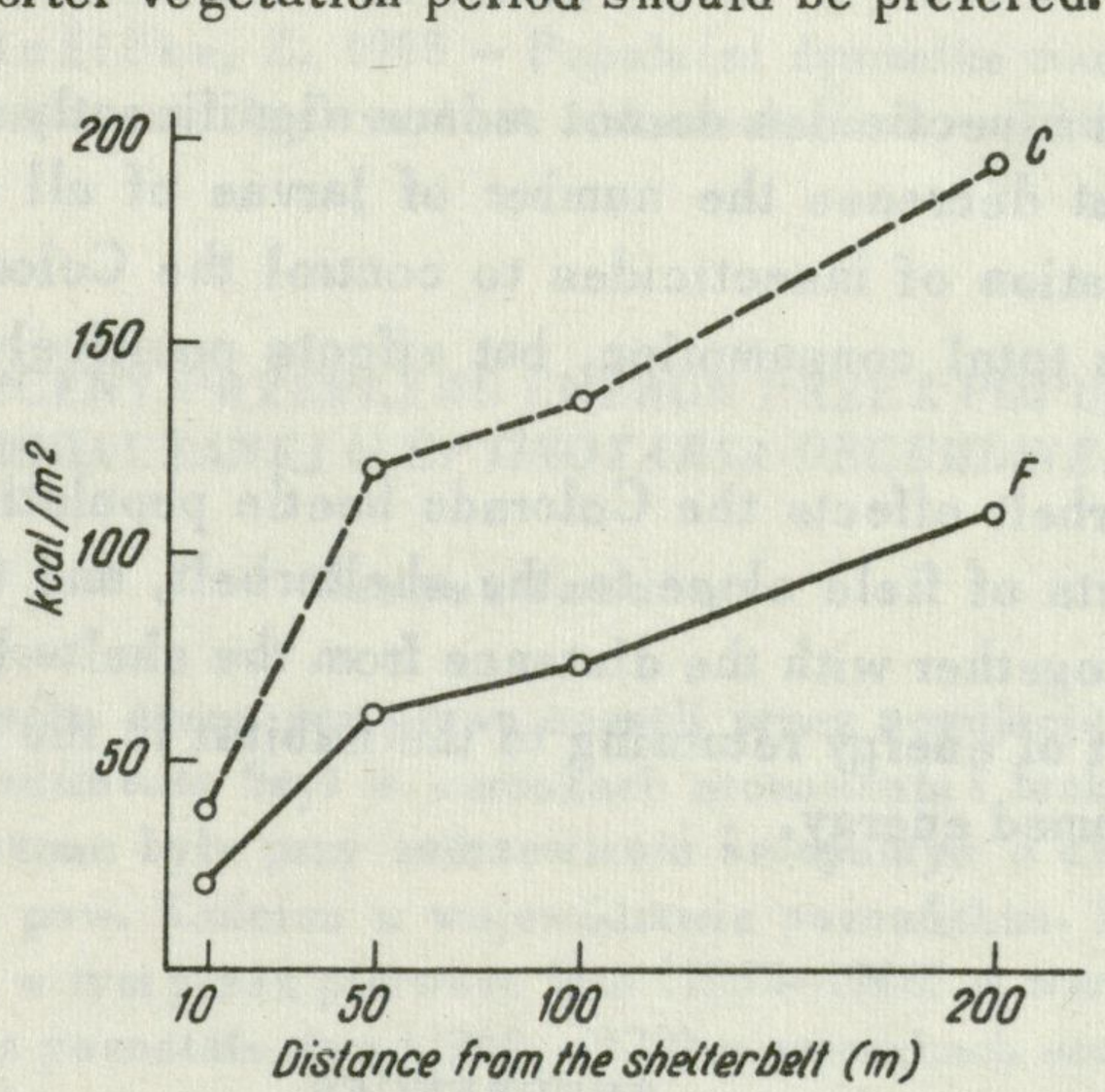

Fig. 6. Consumption (*C*) and faeces (*F*) of the Colorado beetle larvae in different distances from the shelterbelt

The effect of shelterbelts visible in the decrease in number and increase of reduction of particular development stages of the Colorado beetle as the distance from the shelterbelt increases is very distinct when examining the consumption (Fig. 6). The highest consumption values are on the parts of the

field quite far from the shelterbelt. Assuming that on a surface 200 m from the shelterbelt its effect no longer exists and comparing the consumption values of the Colorado beetle on this area to those obtained from the average weighed one for the entire field the profit due to the presence of the shelterbelt can be calculated. In 1970 it was about 7%, which means that the consumption of potato leaves was about 60 kcal/m^2 lower during the whole season. Kukielska (1973) in her studies shows that the yield of potato tubers is also smaller on the surfaces more distant from the shelterbelt.

The larvae and imagines of Colorado beetle produce a considerable amount of faeces (Fig. 6). The ratio of the faeces to consumption is expressed by the value of some 70% for the L_1 stage, 53% for L_2, 39% for L_3 and 59% for L_4. Thus, on the average, more than half of organic matter consumed by the Colorado beetles returns immediately to the habitat in the form of the faeces.

6. CONCLUSIONS

1. The larvae of the last development stage (L_4) and summer imagines of the Colorado beetle are greatly responsible for the consumption of potato leaves.

2. The applied insecticides do not reduce significantly the number of imagines and eggs, but decrease the number of larvae of all development stages.

3. The application of insecticides to control the Colorado beetle does not reduce visibly its total consumption, but affects positively the yield of potato tubers.

4. The shelterbelt affects the Colorado beetle population by decreasing its number in the parts of field close to the shelterbelt, and thus the consumption which increases together with the distance from the shelterbelt.

5. The amount of energy returning to the habitat in the form of the faeces is over 50% of consumed energy.

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PRÓBA OCENY PRZEPŁYWU ENERGII PRZEZ POPULACJĘ STONKI ZIEMNIACZANEJ (*LEPTINOTARSA DECEMLINEATA* SAY)

Streszczenie

Przeprowadzono próbę oceny przepływu energii przez populację stonki ziemniaczanej (*Leptinotarsa decemlineata* Say) w warunkach stosowania i braku ochrony chemicznej. Badane pola położone były przy zadrzewieniu śródpolnym o charakterze pasowym, w Rogaczewie Małym, pow. Kościan w województwie poznańskim. Badania prowadzono od roku 1965 do 1970, w tym przez pierwsze lata (1965–1968) w warunkach braku ochrony chemicznej, a przez pozostałe dwa (1969, 1970) w warunkach stosowania insektycydu („Ditox").

Dane dotyczące liczebności wszystkich stadiów larwalnych, jaj i chrząszczy stonki uzyskiwano drogą lustracji terenowych prowadzonych przez cały sezon w odstępach dwudniowych (Karg, Trojan 1968, Karg, Mazur 1969, Karg 1969). Dane dotyczące budżetu energetycznego larw i imago stonki przyjęto z prac: Chłodnego, Gromadzkiej i Trojana (1967) i Chłodnego (1968). Przeliczeń ilości skonsumowanej zielonej masy liści ziemniaka przez stonkę w ciągu sezonu dokonywano posługując się wzorem:

$$(N_1 \cdot C \cdot T) + [(N_0 - N_1) \cdot C \cdot \frac{1}{2} T),$$

gdzie: N_1 – liczebność (kończąca) dane stadium larwalne stonki
N_0 – liczebność stadium poprzedzającego,
C – wartość konsumpcji w kcal / osobnika/dobę,
T – czas trwania stadium larwalnego stonki.

Całkowita liczebność larw stonki nie wykazuje większych różnic w latach bez ochrony chemicznej i w latach z zastosowaniem insektycydu. Redukcja jest prawie dwukrotnie wyższa w latach z zastosowaniem środka owadobójczego. Konsumpcja osiąga wysokie wartości w latach, w których stosowano insektycydy, ponieważ nie spowodowały one obniżenia poziomu liczebności larw starszych stadiów rozwojowych i imago letniego pokolenia stonki. Zastosowanie insektycydu spowodowało natomiast przesunięcie w czasie okresu intensywnego żeru, co dodatnio wpłynęło na plon kłębów ziemniaka.

Stosunek fekalii do konsumpcji wynosi u larw stonki średnio 50%. Zysk w ilości skonsumowanych liści ziemniaka, jaki wynika z obecności zadrzewienia śródpolnego, wynosi około 60 kcal/m^2 w ciągu sezonu.

AUTHOR'S ADDRESS:
Dr Jerzy Karg,
Zakład Agroekologii
Instytutu Ekologii,
64–003 Turew,
pow. Kościan, Poland